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NASA Helps Airports "Experience the Future"

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Across the globe, air transportation delays are a growing concern within the industry. Further anticipated growth in air traffic is sounding a warning bell that measures to increase capacity are not being implemented at a sufficient rate. Meanwhile, airports are applying considerable resources on expansion projects in many major hubs. Construction of new facilities at airports to handle more passengers and aircraft is an obvious and valid approach. However, in tandem with new runways, taxiways, terminals and gates, airports must also improve procedures to achieve the optimum improvement in capacity. In addition, infusion of the most beneficial new technologies can help improve efficiency and therefore capacity. Well-tested new expansion plans, procedures and technologies that are proven for both current and future traffic loads are what the National Aeronautics and Space Administration's newly opened simulation facility, NASA FutureFlight Central, is all about. By offering the industry a safe, yet highly realistic operational test environment, NASA's goal is to speed the introduction of changes to airports to increase throughput, improve safety and reduce the cost of air travel.

Background

In a joint project with the Federal Aviation Administration (FAA), Ames Research Center, the lead NASA Center for Information Technology, designed a state-of-the-art facility, FutureFlight Central, to simulate air traffic control and surface operations at the busiest U.S. airports. This non-profit facility provides a high fidelity, virtual airport environment where industry as well as government can come to investigate specific problems, study proposals, and perform cost-benefit analyses tailored to their unique needs. To use the facility, the NASA customer describes the specific objectives and requirements for a study. The facility staff then develops a detailed plan for preparation, performance, measurement and analysis. NASA Ames Research Center and FutureFlight Central were ISO 9001 certified in August 1999.

This article describes NASA FutureFlight Central and some ideas for using it for 21st century airport planning. It suggests opportunities to develop targeted, cost-effective solutions to real problems through interactive simulation and modeling.

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NASA FutureFlight Central

FutureFlight Central is designed to replicate to the highest degree practical, the environment in which interactions take place between the major players on the air side of airport operations: the air traffic controllers, the pilots, the ramp operators, and airport operators. This $10 million, two-story structure houses a full-scale tower in the upper story, with a 360-degree, high resolution, out-the-window view, and 12 functional controller positions. Surface and terminal area radar, runway lighting control, weather maps, and communication panels are examples of custom, reprogrammable displays that provide the look and feel of the specific tower being simulated.

For supporting the simulation, FutureFlight Central has 21 stations for pilots, ramp controllers, and airport operators in the lower story. These are real people who provide voice communication with the tower and ramp, and dynamic control of the vehicles in the simulation. Pilots typically hold general aviation licenses or are retired commercial or private pilots. Each pilot in the simulation actually monitors several vehicles. The routes are preprogrammed, but the pilot can override them and reroute aircraft dynamically. The vehicles are aircraft in various stages of flight or ground vehicles such as baggage carts, fuel or fire trucks.

Authentic headsets, located at each controller, pilot, ramp and operator station, support fully functional simulated radio and interphone communications. A touchscreen panel emulates the panel of switches used to select among a wide array of voice communication channels. Airport background sound effects in the tower add to the operational realism.

Key Features

Several key features combine to create the realism that gives credibility to studies performed in the facility. Perceptual fidelity is important to permit valid transfer of data to real-world situations.

<u>High Resolution 3D Graphics</u>
A state-of-the-art image generation supercomputer produces a visual scene of unprecedented realism from the control tower. The graphics incorporate high-resolution three-dimensional objects, shadow effects, near-photographic quality imaging, and smooth animation of up to 200 simultaneously moving models. The busiest airports can be modeled using the computational power provided by 100 Pentium processors, combined with the graphic display capability. The scene is generated by twelve high-resolution video projectors on twelve rear-projected 7 x 10-foot screens joined seamlessly to form a continuous 360-degree view. Glass panes with support mullions separate the control tower occupants from the screens.

The software enables repeat trials under varying conditions such as different times of day, weather conditions, or traffic loads. For example, a new runway could be tried at different locations on the field while applying identical traffic loads to each trial. This is a valuable feature when the goal is to choose between multiple designs or procedures, to perform trade-off studies, or to verify a proposed design by testing under all possible conditions. FutureFlight Central can simulate a continuous spectrum of daylight from dawn to night. Weather effects include clouds at various ceilings and densities, fog at any level of visibility, rain, and lightning.

Realistic Traffic Scenarios

Real traffic scenarios can replicate variations in traffic loads over a given period of time. If the simulation requires, scenarios can even project future traffic loads. Incidents can be staged such as a runway incursion, an emergency on the field, or obstruction on the taxiway. Visual representation of specific aircraft types and airlines liveries, and accurate aircraft performance parameters, tailor the scenarios to the airport being simulated.

Human Interaction

Computer-based airspace-modeling tools approximate delays based on estimates of human response. However, as the complexity of the job increases due to specific airport conditions such as ground vehicle traffic or communication workload, response times for both controller and pilot are compromised. By using real people as pilots, ramp and airport operators, the FutureFlight Central environment more accurately replicates the variability that humans add to real life operational problems. This ensures that new expansion plans, procedures, and technologies are thoroughly tested for all situations and users, and allows greater confidence that they are ready for deployment.

Safety

Used extensively for many years for aircraft design, development, testing, and training, simulation can afford the same benefits to air traffic control and ground operations. Controllers can participate in site evaluation and operational testing without disrupting real airport operations. This allows them to provide feedback early on in the design of tools and technologies in the same way they eventually will be used but without impacting safety. They can concentrate more fully on evaluating, improving or learning new procedures and tools. The result is a faster development process, safer introduction, and greater acceptance of change.

Flexibility

FutureFlight Central was designed to be reconfigurable to replicate any airport by using site-specific visual databases, displays and tower layout, and custom designed traffic scenarios. Programmable touchscreens in the tower depict the ground, local, flight data/clearance delivery, and traffic manager displays unique to that airport tower. Examples are terminal area radar (ceiling or work surface mounted), surface radar, weather displays, or aircraft situation display. The three-dimensional airport model makes

viewing possible from other locations than the tower, for example, a ramp tower or a pilot's view from the cockpit.

Data Analysis

Most importantly for a simulation study, the results are quantifiable. Data can be collected and monitored during the simulation as well as stored for later statistical analyses. Engineers can record the constantly changing visual scene, all audio communication and in-tower video for each scenario. These recordings can be played back for comparisons, analyzed for a specific occurrence, and/or combined into a final report. A visual reinforcement to a report is a powerful advocacy tool to convince stakeholders of the merits of an airport project.

Opportunity #1: Optimize Capacity Gains in Airport Expansion

Airports employ a number of measures to improve capacity. By simulating design alternatives in advance including accompanying procedural changes with all human participants in the exercise, overall gains in capacity can be accurately measured. For example, a major U.S. airport currently considering the addition of a runway can answer these questions: How much will the additional runway increase daily throughput? Will arrival capacity be increased at the cost of departure capacity? Will our current air traffic control staff be able to manage the additional workload? What is the best way to divide ground traffic responsibility among tower personnel? What surface areas can be used to hold aircraft? Where are bottlenecks likely to occur? Is our current gate turn-around adequate to handle the increase in traffic?

Unfortunately, as with freeway expansion, airport expansion projects often offer short-lived relief, as demand quickly grows to fill the reserve capacity that was created. This stems from the long lead times required for such projects and the inability to accurately predict the operational impact of future traffic loads. FutureFlight Central can reliably model how facility modifications, still in the planning stages, will respond to future traffic projections, and if they will continue to provide a positive return on the investment well into the future.

The safety-critical nature of on-going operations severely restricts the ability to try many different solutions. Until now, no facility or tool existed that allowed planners to completely evaluate proposed procedural changes without impacting real operations. FutureFlight Central safely models the airport to a level of sophistication and realism that is required for subsequent implementation in the real operational environment.

Opportunity #2: Test-drive New Technologies Before Investing

Until recently, relatively little had been done to leverage new automation technologies for airport operations. Instead, the focus was on equipment upgrades, which the industry and

government view as a more pressing problem. Modernization of equipment and information systems used for air traffic control has been a slow process, and it has complicated and delayed the introduction of new technologies.

Many new concepts spend years in the development and evaluation phase. Access to field testing sites is restricted in many cases because of safety concerns or because of extensive configuration changes already underway. Among technologies identified as critical for the implementation of FreeFlight Phase 1 are those to reduce the growing trend in runway incursions, digital communication to offload voice channels, computer-aided vision systems for reduced visibility operations, and centralized accurate flight schedule information for better planning.

However, every airport is different, and may thus benefit to varying degrees from a particular investment in technology. The inherent safety and flexibility of FutureFlight Central provides a platform to adapt new technologies to the unique configuration of each airport, and to analyze them for cost-benefit.

Opportunity #3: Analyze Surface Operations to Improve Safety

The safety risk associated with increases in air traffic density is evident in an upward trend in airport surface incidents and accidents. Incidents on the runways, defined as an aircraft, vehicle or person on a collision course with another aircraft that is landing, taxiing or taking off, have increased steadily since 1988.

Simulation can stage hypothetical situations such as a variety of emergencies, and study the ability of existing or proposed procedures to adequately deal with them. It can vary conditions of weather, traffic and equipment performance.

By moving the viewpoint from the tower to other locations on the field, or even inside the cockpit, line-of-sight and other visibility issues can be analyzed not only from the controller's point of view, but also that of the pilot or ground vehicle operator. On the runways, airports can improve the efficiency and safety of procedures for reduced visibility conditions such as reduced operations, changing landing direction, and coming back to full-up operations after a ground delay. Refining controller procedures for land and hold short operations (LAHSO), or allowing controllers to participate in developing missed approach procedures, are examples of other safety-related applications appropriate for FutureFlight Central.

Summary

A simulation study in NASA FutureFlight Central is a cost-effective way to plan airport expansion, assess the return on technology investment and analyze safety. In addition to

developing the best design or procedure, a cost-benefit evaluation using real traffic scenarios can help determine if the change is worth the investment.

International airports, airlines and industry consultants are welcome in the FutureFlight Central facility. A first step in the process is submitting a simulation request, which outlines the simulation objectives, requirements for software and hardware development or integration, and data recording and analysis. To obtain a Simulation Request Form or for more information, see the FutureFlight Central web page, http://ffc.arc.nasa.gov.